# The astrometric study of the triple system ADS 9173.

**Kiyaeva O.V.**

Pulkovo observatory, e-mail: kiyaeva@gao.spb.ru

**Abstract.** The preliminary orbit of the wide pair ADS 9173 A-Bb is obtained by the Apparent Motion Parameters (AMP) method on the basis of Pulkovo 26-inch refractor uniform observations 1982-2004 using observations from WDS catalog 1832-1980 and Hipparcos parallax. The spectroscopic orbit B-b is supplied by the elements i and Ω on the basis of deviations relative to the A-Bb orbit. The planes of the orbits are close to coplanarity. Pulkovo observations indicate perturbations with a period more than 13 years. Probably the component A is also an astrometric binary.

Keywords: stars: binaries (including multiple): visual – stars: individual (ADS 9173)

**Introduction.**

The visual binary ADS 9173=WDS 14135+5147 was discovered by F.G.W. Struve in 1822. The relative motion of the pair AB is very slow, and the arc covered by observations is very small. The primary component A is δ-Scooty variable. The secondary component B is a single line spectroscopic binary with a period 4.9yr. (Bakos, 1986). The data about the star is presented in tabl.1.

**Tabl.1. The Data about the star.**

| Comp. | Parallax ["] | $\mu_x$ ["/yr] | $\mu_y$ ["/yr] | $V_r$ [km/s] | m | SP | Mass [Sun] |
|---|---|---|---|---|---|---|---|
| A | 0.02103 ±0.00083 | 0.0614 ±0.0009 | -0.0106 ±0.0008 | -23.0 - | 4.54 | A8IV | 1.9 |
| B+b | 0.01666 ±0.00478 | 0.0646 ±0.0094 | -0.0038 ±0.0072 | -21.5 ±0.4 | 6.69 | F8V | 1.2+0.5 |

We took the parallax and proper motions from Hipparcos catalogue; radial velocities – from Bakos (1986), magnitudes, spectral classes and masses – from the multiple stars catalog (MSC, Tokovinin, 1997).

Our purpose is to determine the preliminary orbit of the wide pair A-Bb and to analyze deviations relative to the orbital motion on the basis of Pulkovo 26-inch refractor uniform observations and the Apparent Motion Parameters (AMP) method.

**AMP-orbit of the pair A-Bb.**

To compute an orbit with the AMP technique (Kiselev, Kiyaeva, 1980), one must know the parameters of apparent relative component motion at the moment $t_o$: position (ρ,θ), relative velocity μ, its position angle ψ and radius of curvature $\rho_c$. We must also know the trigonometric parallax $p_t$ and relative radial velocity $\Delta V_r$. Two uncertainties remain, the unknown parameters being (1) the total mass of the components and (2) the sign of the inclination of the radius-vector of the star with respect to the sky plane (in front of or behind the sky plane).

The second uncertainty is always resolved if the old observations are available, but we can estimate the total mass only when other parameters are determined well enough and old observations cover essential arc. We analyze many AMP-orbits and chose trajectory that fits old observations the best. Usually we can estimate only the minimal value of total mass. If the precision of other parameters is not satisfactory, any AMP-orbit trajectory fits old observations. Thus we can test our solution.

The relative radial velocity is the necessary parameter to determine the AMP-orbit. Probably, the radial velocity of the component A is not constant (Abt, 1965, Malaroda et al., 2005). As shown bellow, our Pulkovo observations indicate that A may be astrometric binary with a long period. Therefore we consider this orbit as preliminary one.

The following apparent motion parameters are obtained on the basis of Pulkovo 26-inch refractor photographic observations 1982-2004.

$t_o = 1993.0$

$\rho = 13.583 \pm 0.004$ [″]

$\theta = 235.553 \pm 0.016$ [°]

$\mu = 0.0054 \pm 0.0006$ [″/yr]

$\psi = 221.3 \pm 6.1$[°]

The orbit of ADS 9173 is determined with limited precision. The curvature radius and the relative radial velocity are selected according to the best agreement with the most reliable old observations (from 126 WDS positions were selected 35 reliable positions which were fulfilled with aperture telescope more than 10, number of observations more than 3). Their values with formal errors are following:

$\rho_c = 18 \pm 1$ [”]

$\Delta V_r = +1.5 \pm 0.2$ [km/s]

Note that the value $\Delta V_r$ fits the value from the Bakos’ article. We took the parallax of the component A (its error is less) and thus we suggest that the pair is not optical. We suggest also that the total mass of the system is equal to 3.6 solar mass (**tabl.1**). The orbital elements are presented in **tabl.2**. The errors of the orbital elements depend on the errors in initial data. The influence of the mass error is essentially less than that of other parameters. The agreement of the orbit with observations is presented in **fig.1a,b,c**.

The observing arc of the pair A-Bb is very small and the orbital elements are determined with great errors, but the plane of the orbit is determined reliably. The trajectory fits all observations from 1832.

The deviations of Pulkovo observations in the directions x-ost and y-nord are presented in **fig.2**. They indicate the long periodic perturbations (**fig.2b).**

The component A may be also astrometric binary, but we cannot to determine the period now. This suggestion fits variable radial velocity observations.

**The photocenter orbit of the pair B-b.**

The orbit of the photocenter of the pair B-b with fixed values of the period P=4.9 yr. and $T_o$=1996.245 is determined on the basis of spectroscopic orbit data and Pulkovo observations deviations (fig.2).

**Tabl 2. The orbital elements.**

| Pair | a [”] | P[yr] | e | i [°] | ω[°] | Ω [°] | T[yr] |
|---|---|---|---|---|---|---|---|
| A-Bb | 11.4 ±5.5 | 6675 ±5241 | 0.5 ±0.4 | 99.5 ±4.7 | 25 ±67 | 53.2 ±4.7 | 6870 ±1943 |
| Photocenter B-b Result | 0.019 ±0.010 | 4.904 | 0.6 ±0.1 | 83 ±20 | 70 ±39 | 54 ±24 | 1996.245 |
| Photocenter B-b spectroscopic | a*sin(i)= 1.0AU | 4.904 | 0.53 | - | 96 | - | 1996.245 |

Since the A-Bb orbit is preliminary one we use deviations relative to rectilinear motion 1982-2004. To smooth out the effect of long periodic perturbations we obtain mean positions in the window of phase which is equal to 0.05 relative to period previously.

Our purpose is to supply the spectroscopic orbit by the orbital plane elements (i and Ω) and to obtain the orbit which fits both astrometric and spectroscopic observations. Perturbations with a period 4.9yr are discovered mostly in the single direction in the sky plane (the direction of maximal effect, node line). It means that inclination is high enough. The best solution for astrometric observations corresponds to $\omega=40^{o}$ (**orbit 1, fig.3a,b,c**), but it does not fit spectroscopic radial velocity observations. As a result we obtained $\omega=70^{o}$. This orbit is presented in **tabl.2** and **fig3.** We presented also the spectroscopic orbit elements for comparison.

To estimate the precision of the calculated orbital elements we simulated 20 series of observations for the real observational epochs but randomly distributed around real series with a dispersion of 30mas. The dispersion of the sets of the orbital elements derived from the simulated series is taken as the precision of the orbital elements.

Comparing the orbits of the pairs A-Bb and B-b we see that the planes of the orbits are close to coplanarity.

## Conclusion.

We obtained the AMP-orbit A-Bb assuming that it is a physical pair. However several uncertainties remain. There is uncertainty in component A radial velocity observations (Abt,1965; Bakos,1986; Malaroda et al.,2005), period of long periodic perturbations isn't determined. Therefore we consider that our results are preliminary.

The star is very interesting. May be it is a quadruple system. To investigate this problem it is necessary to have longer series of observations.

We express our thanks to A.A.Kiselev all observers of Pulkovo 26-inch refractor, and also to B.D Mason and all creators of WDS database.

Fig.1a. Orbit A-Bb in the sky plane.

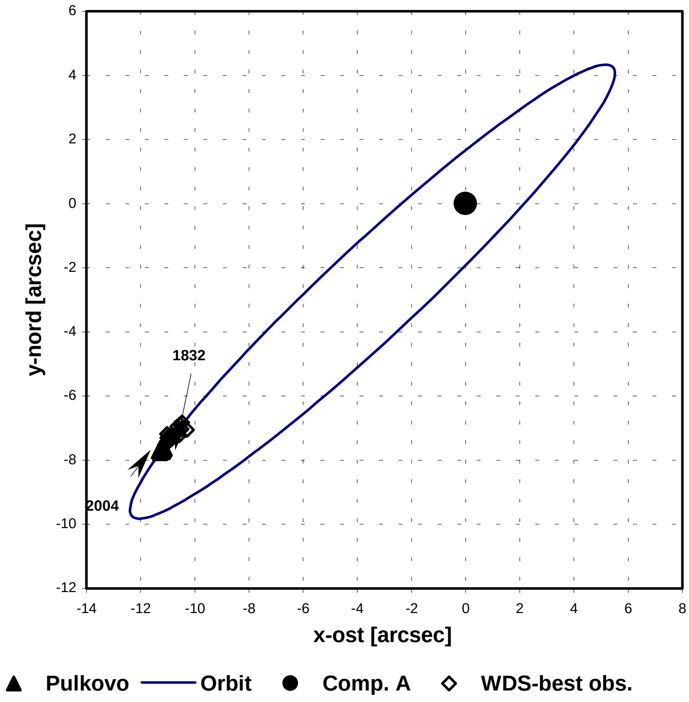



Fig.1b. Pair A-Bb, ρ(t).

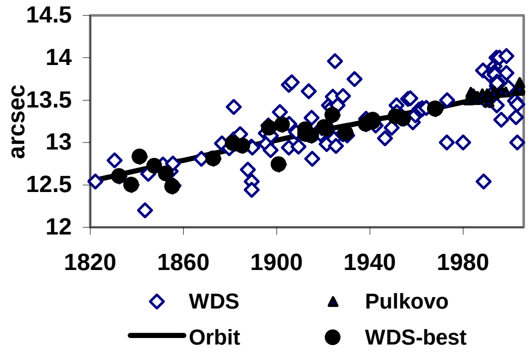



Fig.1c. Pair A-Bb, θ(t).

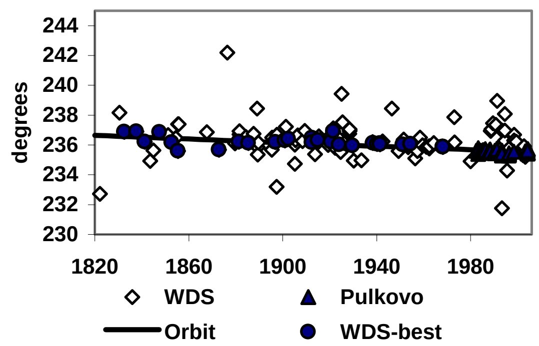



Fig.2a. Pulkovo observations deviations x(t)-ost.

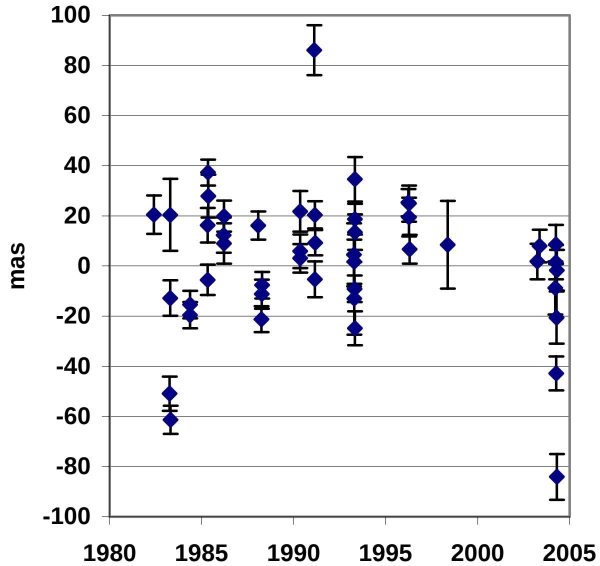



Fig. 2b. Pulkovo observations deviations y(t)-nord.

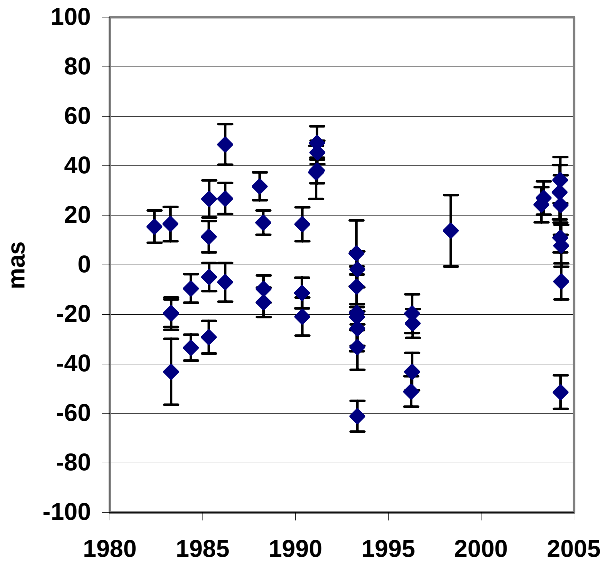


Fig.3a. Determination of the orbit B-b. Deviations in the direction of maximal effect, To=1996.245.

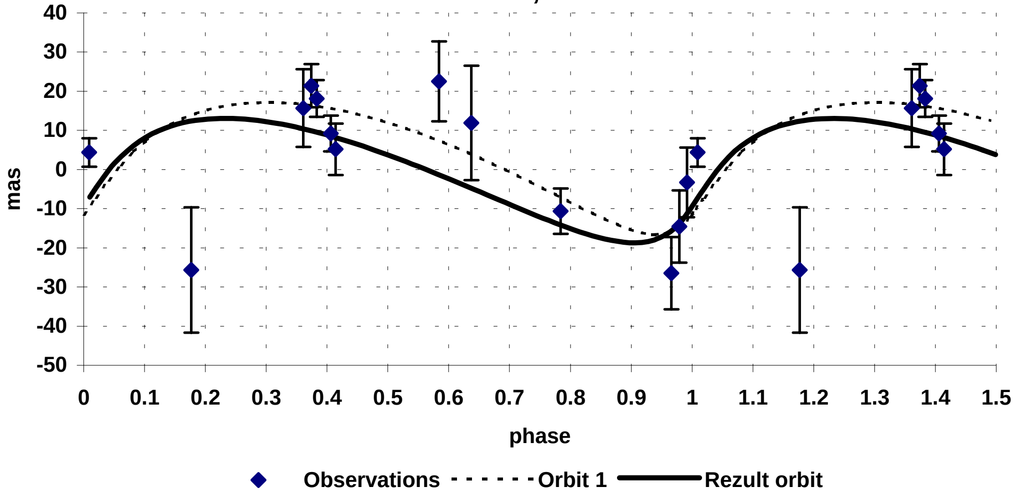



Fig.3b. Pair B-b, x(phase), To=1996.245

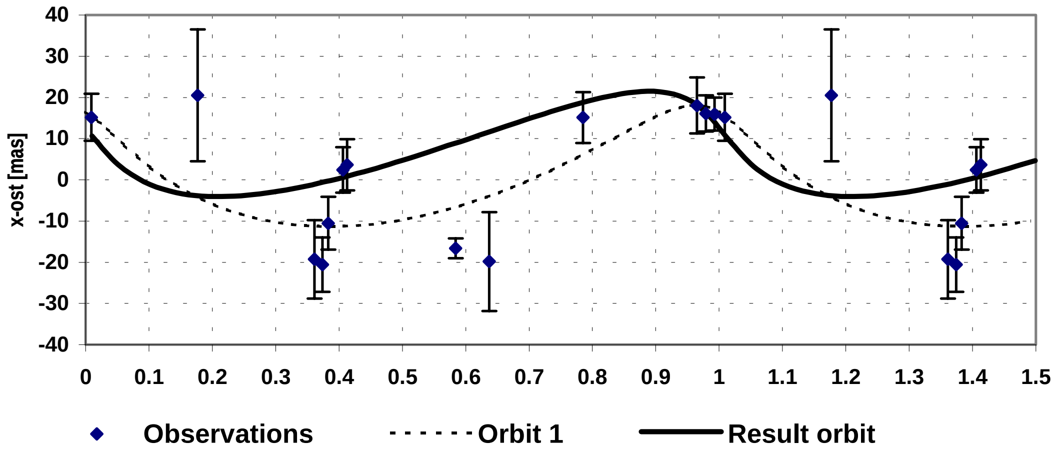



Fig3c. Pair B-b, y(phase), To=1996.245.

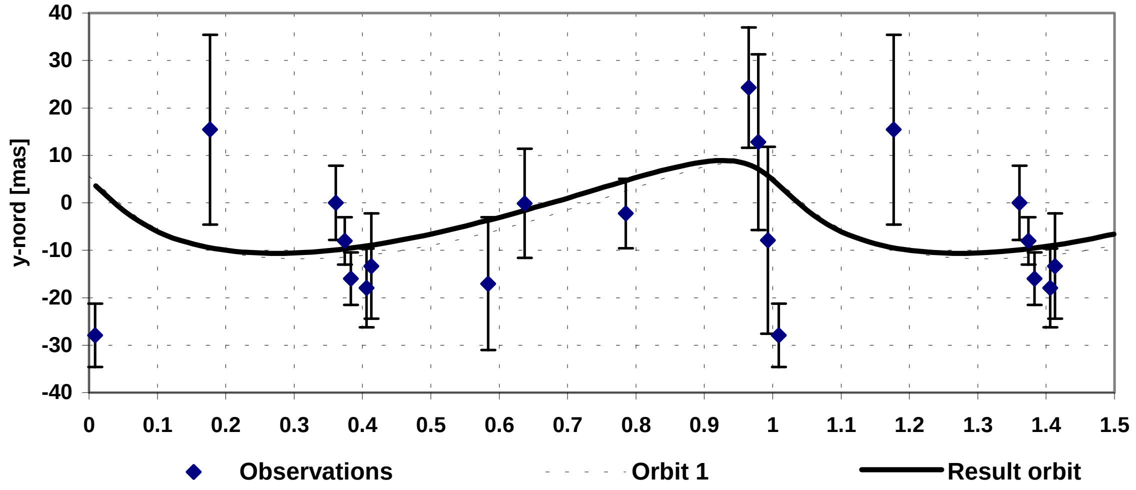
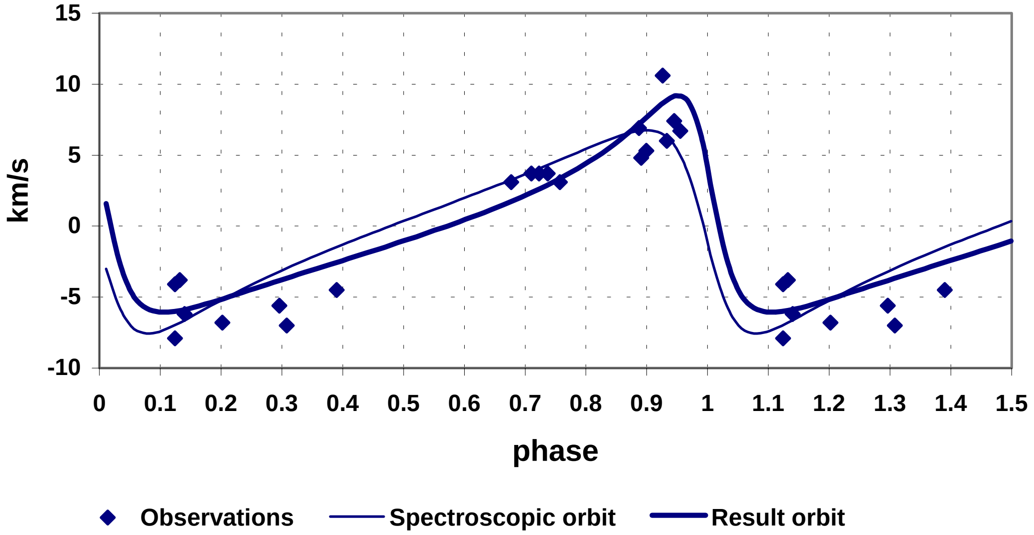


**Fig 3d. Orbit B-b. Relative radial velocity as a function of phase, To=1996.245.**




REFERENCES

1. Abt H.A., Astrophys.J.Suppl.,V.11,P.429(1965).
2. Bakos G.A., Astron.J.,V.91,P.1416(1986).
3. Kiselev A.A. and Kiyaeva O.V., Astron.Zh., V.57, P.1227-1241(1980) [Sov.Astron.,V.24,P.708(1980)]
4. Malaroda S., Levato H., Galliani S., *Bibliographic catalogue of stellar radial velocisies (1991-2005).* http://www.casleo.gov.ar/catalogo/catalogo.htm
5. Tokovinin A.A. *MSC - a catalogue of physical multiple stars*. Astron. Astrophys. Suppl. Ser. V. 124, P. 75-84(1997) http://www.ctio.noao.edu/~atokovin/